Abstract

Over the last decade, general purpose Truth Maintenance Systems (TMSs) have been developed and applied in a number of domains. One of the reasons for the development of TMS is that it enables search programmes to carry results obtained in one part of the search space to other parts. Among the non-monotonic reasoning systems, TMSs have a special place since these are the only systems which provide a constructive approach towards building practically useful inference engines working with incomplete knowledge.

Prime implicants play a significant role in many reasoning systems. There have been numerous techniques reported in the literature to compute the prime implicants of a formula. As a logical framework of Assumption-based TMS (ATMS), Reiter and de Kleer [Reiter 87] suggested a notion of knowledge compilation in a Clause Management System (CMS). It has also been suggested that for this purpose, the Slagle's method to compute the prime implicants is better than a simple consensus method. Recently, Socher [Socher 91] proposed an algorithm using a concept of prime path in a binary matrix. This method provides a better technique to compute the prime implicants. Nevertheless, Socher's algorithm perform far more computations than required.

In the present work, the properties of prime paths in a matrix are studied in detail. The paths which contain a literal and that which do not contain a literal are characterized. Based on this characterization, a scheme is proposed to partition the matrix representing the formula. The fact that the prime paths of a matrix can be obtained by the concatenation of prime paths of two submatrices, is established theoretically. A concept of the extension of a path in a submatrix to a larger matrix is proposed and the Prime Implicant Algorithm using Paths and Extension (PIAPE) is designed. It may be noted that subsumption is the crucial operation in any prime implicants algorithm and the actual execution time depends critically on the number and expense of
the subsumption checks that are required. It is established that extension is nothing but a sort of subsumption. In order to achieve efficiency, paths which neither subsume nor are subsumed by any other path are characterized. Further, the number of subsumptions can be reduced by generating less number of paths which are not prime. Hence, a better method to weed out paths that are not prime in a bigger matrix is proposed in this dissertation. The new algorithm *Prime Implicant Algorithm using Paths* (PIAP) a refinement of PIAPE is efficient in terms of number and expense of the subsumption checks required.

A new tree-structure for knowledge representation proposed in this dissertation naturally evolves from the partitioning scheme of PIAP. The structure of a node in the tree, and the implementation details of PIAP are explained. Experiments are conducted to compare the efficiency of the algorithm, and the results obtained substantiate that the proposed algorithm is far better than Socher's algorithm. The tree-structure is also used to maintain the prime paths. The efficiency of the method hinges on this tree-structure and the same structure helps design a novel RMS. Hence, it is named *TERMS: Tree-structured Reason Maintenance System*.

The PIAP is well suited for incremental computation of prime paths, which is necessary for RMS update problem. Different methods to update the tree representing the formula as well as methods for incremental knowledge compilation are discussed. The advantage of this method over other methods is that the additional knowledge is treated collectively for compilation. Thus, the method is better than other methods, both in global and incremental mode.

Apart from these advantages, the PIAP exhibits inherent parallelism. The potential for concurrency is explored, and the parallel algorithm, PARPIAP to compute prime paths is also designed. The different granularity levels are explored and the architecture suitable for each, and finally, a hybrid architecture suitable for PARPIAP is proposed.
Though the prime implicants paradigm is a widely used tool in many areas of AI, one particular application of it, in the area of computer vision, is discussed. The problem of shape from silhouettes is rephrased as a problem of computing prime implicants of a formula obtained from the object silhouettes. It is demonstrated that the proposed framework is better than the conventional algorithmic approach, namely, Volume Intersection.